UNF UNIVERSITY of NORTH FLORIDA
College of Computing, Engineering & Construction

Federal Communications Commission
Washington, D.C.

Regarding reply comments on alternative delivery services for NOAA GRB and HRIT data:
WT Docket No. 19-116,
Notice of Proposed Rule Making and Order,
Allocation of Service Rules for the 1675-1680 MHz Band

July 21, 2019

Introduction

The FCC requested comments in the subject docket regarding their proposal to allocate the spectrum between 1675 MHz and 1680 MHz for terrestrial fixed and mobile use. I submitted comments in this docket on June 21, 2019. Ligado filed an ex parte presentation in the docket on June 13, 2019 and comments on June 21, 2019. The presentation and comments filed by Ligado contain significant errors and demonstrate that they still do not understand how NOAA and the weather community use the GOES satellites. Further, their comments continue to advocate for a replacement communications solution that has already been shown to be unacceptable because it does not match the performance of the current GRB network and it will put lives in danger unnecessarily.

The errors within the Ligado presentation and comments are so numerous that I am submitting two sets of reply comments to address them. This set of reply comments is focused on how best to deliver NOAA GRB data (and HRIT data). A separate set of reply comments addresses Ligado's misunderstanding of the use of the GOES satellites by the weather community and also their misunderstanding of the usefulness of the NOAA interference study that is currently in process. Both sets of reply comments are intended to assist the FCC by providing input for them on the many requests for comments they included in the NPRM.

What is Wrong With Ligado's CDN Proposal

Despite the very clear letter filed by the American Meteorological Society, The American Geophysical Union, and The University of Wisconsin-Madison under FCC RM-11681 on April 10, 2017, that explains the technical reasons why the Ligado Content Delivery Network (CDN) solution will not work for delivering GRB data, Ligado, who markets themselves as a satellite telecommunications company with the motto "Making Stronger Connections" continues to suggest that their proposed terrestrial CDN will work. As an accomplished and experienced telecommunications consultant and assistant professor of electrical engineering, with 30 years of experience in both satellite and terrestrial communications it is my opinion that Ligado is wrong. Their CDN will not meet the current availability requirements for GRB and the resulting latencies in delivering data will delay weather forecasts that could warn citizens of tornados, tsunamis, volcanic ash plumes and hurricane movements and as a result put their lives and their property in danger. As a telecommunications engineer, it is particularly egregious to me that a telecommunications company in my industry, would advocate for such a flawed and obviously weaker connection.

Network Availability and Why it Matters

One of the keys to understanding why the Ligado proposal is not viable is in understanding why the proposal cannot meet the same availability offered by the current NOAA GRB service: 99.988%. The HRIT service requires much less

bandwidth than GRB so we will focus on GRB (if you can design a network to carry GRB than you can support HRIT). Consider the layout of the current GRB delivery service scheme through GOES. It is shown in Figure 1. Note that the only communications network component is the GOES satellite. In contrast the delivery service proposed by Ligado requires multiple distinct components centered on a cloud service provider such as Amazon Web Services (AWS). To implement such a service the NOAA generated GRB data stream would need to be first uploaded to the cloud service and then downloaded to each user that wants to receive the data. The upload of the GRB data must come from NOAA so that they can create, manage, and oversee its content using the raw sensor data-streams that only NOAA receives from the GOES satellites. Quite simply, the source of the uploaded data must be from one of the current NOAA GRB and HRIT generation locations. All of the required distinct components that would be needed to support the CDN service proposed by Ligado are shown in Figure 2. The diagram is a simple network connectivity diagram that is of the type typically used to compute network availabilities.

Figure 1. The current GRB service delivery scheme.

Figure 2. Ligado's proposed delivery service.

The Ligado proposal suggests that the cloud services at the center of Figure 2 could be provided by Amazon Web Services (AWS) using their Elastic Compute Cloud (EC2) and cloud storage products. In their ex parte presentation, submitted in this docket, Ligado references an AWS document that indicate AWS services can achieve 99.99% availability. The AWS document also indicates that individual EC2 installations (think virtual servers) have an availability of 90%. Using the information about AWS availability we can redraw Figure 2 to account for the AWS services needed to support both the uploaded data from NOAA (the input side of the cloud service) and the downloaded data going to users (the output side of the cloud service). They are separate pieces of the AWS service cloud and the availability of each must be accounted for, along with the actual data server itself. The adjusted scheme is shown in Figure 3.

Here is where Ligado runs into trouble with their proposal. As a telecommunications company I am quite surprised that Ligado made such a big mistake in trying to design a relatively simple network and analyze its availability. They assumed that the connections between NOAA and the AWS cloud service and between the AWS cloud service and the downstream users are trivial and don't impact the availability of the complete connection between NOAA and the users. In the ex parte letter Ligado only addresses the last mile connection and states that "many highly reliable, dedicated internet products are available on the market…" and then follows with "last mile delivery should not negatively impact delivery of the NOAA data via [the proposed content delivery service]".

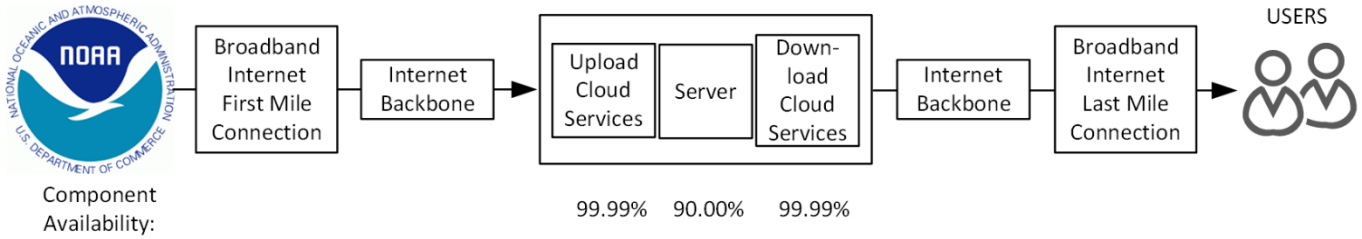

Figure 3. Ligado's delivery service assuming Amazon Web Services for the cloud.

The first and last mile connections cannot be ignored in computing availability or in analyzing network vulnerabilites. This is a fundamental concept in network design and availability calculations. We will need the first mile and last mile availability numbers to complete the calculation as well as the availability of the internet backbone. The highest possible availability for a broadband internet connection service is 99.999% and it is offered for instance by AT&T[1]. This is the so-called 5-9's of availability associated with carrier class services. For this exercise we will assume that this grade of service would be deployed for the first mile. Notice this first mile internet service is referred to here as an internet "connection" service. The internet itself is a backbone network that connects the entire world together through very high speed, redundant network connections. This global internet backbone is separate from the broadband internet connection service that we pay for as users to access the internet. If an internet backbone network connection goes down in Germany that prevents you from doing business in Europe, AT&T does not reimburse you since the broadband connection to the internet that they provide you is still operating.

As for the last mile internet service, Ligado suggests, in their ex parte comments mentioned above, that Comcast's dedicated internet service is a possible solution a user may deploy for their last mile connection and present its availability as 99.9%. For this exercise, lets assume the Comcast service is used for the last mile, in particular because the more reliable carrier-class broadband internet service we selected for the first mile is expensive and not available at every customer location in the US. For the internet backbone we will also assume carrier class service and assign availability numbers of 99.999% for each of the two required internet backbone connections. Although there is only one "internet backbone" the paths through the backbone traversed by the upload link and the download link are separate and therefore require separate availability numbers. This assumption of 5-9's of availability for the internet backbone may be generous for the cross-country connections that would be necessary to deliver NOAA data to the mid-west or the west coast. The proposed network with the additional availability numbers is shown in Figure 4. To determine the end-to-end availability of this sequential combination of components, we simply multiple the component availabilities together. The resulting calculation shows that the CDN proposed by Ligado has an availability of 89.889% for the end-to-end connection between NOAA and the GRB users. This is significantly lower than the specified availability of 99.988% provided by the current GRB service.

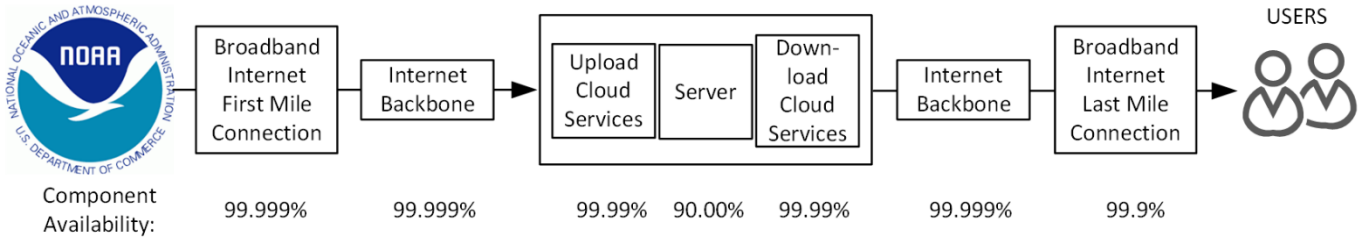

Figure 4. The Ligado delivery service with AWS and AT&T high-end first and last mile connections.

[1] [1] https://www.business.att.com/products/dedicated-ethernet.html

It is possible to increase availability with redundancy. For instance, if the single server is made redundant and replaced with a large combination of 5 completely redundant servers then the server availability increases from 90% to 99.999%[2]. This will increase the end-to-end availability to 99.876% which is still not as good as that of the current GRB service. In fact, with the 5 servers, even if a GRB user was willing to pay for redundant Comcast connections between themselves and the AWS cloud service, the end-to-end availability would increase only to 99.977%, still falling short of the current GRB availability of 99.988%. Even including redundant 5-9's upload paths from NOAA to the internet will not improve the availability in any significant way. The constraints of building a complex terrestrial content delivery network simply cannot match the performance of the current GRB delivery system.

I want to note that the above calculations omit any downward adjustments for the recent history of service failures that Amazon and the internet service providers have experienced that were not attributable to equipment failure. Service level agreements that use availability figures like 99.999% take into account only equipment failures that are computed from probabilities that a particular component will fail. These availability calculations do not include damage caused by significant natural disasters, bad actors, and human operator mistakes. While the same can be said for the availability of the current GRB service onboard the GOES satellite it seems to me that the threat of terrestrial network service outages far outweighs the threats in geostationary orbit. The extended outages experienced by Amazon when internal mistakes are made, or the extended outages experienced by Verizon during hurricane Michael are not part of the availability calculation but they would be part of the delay in receiving data that might cost lives and the loss of property if the delivery of GRB and HRIT data must tolerate them during emergencies.

It is also important to note that internet service providers do not define service outages at the granularity that many GRB and HRIT users might expect. While any loss of signal from the GOES satellite may register as an outage or packet loss to a current GRB or HRIT user, in the internet, outages are not defined so tightly. For instance, some Verizon dedicated internet services use two failed pings of a customer's equipment, spaced five minutes apart, to define the start of an outage. That means an actual outage of just less than 10 minutes, may not be a service outage as defined in a service level agreement and no action by the internet provider would be warranted. Similarly, Comcast, with its 99.9% availability can experience a 45 minute outage every month and still claim they have provided the agreed upon service. With Comcast, the service outage does not begin until a trouble ticket is created, which often happens after a customer detects the outage, calls Comcast customer service, and then waits while they establish that the problem is a Comcast problem, and not a customer problem or an internet backbone problem. Including the time to initiate a trouble ticket, an actual outage may be an hour or more and still not actually impact the Comcast availability calculation if they restore service before the trouble ticket ages 45 minutes. An hour without tornado warning data or tsunami warning data could easily mean the difference between life or death. If such outages are not included in the availability calculations, and the availability calculation is already insufficient, then clearly Ligado's proposed content delivery network is not an acceptable solution for delivering GRB and HRIT

The Solution Is…

Of course, the first best solution to delivering GRB and HRIT content to future federal and current and non-federal users is to provide interference protection to all of them. If that is not possible, then ensuring that the 1675-1680 MHz band is used only for uplink spectrum will significantly reduce the incidences of interference for many unprotected users and also easily allow for the addition of future earth stations by implementing geo-fencing in terrestrial non-federal subscriber units so they do not transmit in the band when they are near a protected GRB or HRIT earth station. With multi-band phones and service the customer would hopefully not even notice.

Going further, for a content delivery solution that will avoid interference altogether and maintain or exceed the high availability of the current GRB system, a delivery network that looks a lot like the current GRB network is needed.

[2] Parallel combinations of availability elements require a more complex calculation. For instance, if 3 elements with component availabilities of A, B, and C are placed in parallel then their parallel combination will have an availability of 1-(1-A)*(1-B)*(1-C).

Direct broadcast of the GRB and HRIT content over commercial satellite services is a potential solution. Such services at C-band are known to achieve 99.99% availability which is sufficient to support GRB. A redundant combination of two C-band channels on different satellites would ensure that those requiring the most reliable and timely GRB and HRIT data would be supported at all times, even if one service needed to change transponders or satellites. By adding a third link at K-band, users who can tolerate less reliable GRB and HRIT links can receive the data with a significantly smaller earth station installation. Assuming an off-the-shelf link solution is used (perhaps DVB-S2), the cost of the C-band and K-band earth station hardware would be low compared to even that of a GRB earth station. Recurring spectrum usage fees, charged to the new non-federal terrestrial users, could replenish a financial trust established from the auction proceeds that pays for the commercial satellite-based content delivery system until such time as NOAA migrates to a new version of DCS, GRB, and HRIT in new spectrum perhaps 15 to 20 years from now.

Should you have any further questions regarding these comments please do not hesitate to contact me.

Regards,

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